Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of:

	)	
Unlicensed Use of 6 GHz Band	)	GN Docket No. 17-183
	)	ET Docket No. 18-295
	)	

COMMENTS OF DECAWAVE

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EXECUTIVE SUMMARY

While Decawave is not opposed to sharing the spectrum with broadband access systems, we have several concerns about the published Notice of Proposed Rulemaking (NPRM) in GN Docket 17-183 and ET Docket 18-295.

Sharing studies, in the annex to this contribution, show that UWB systems will not be able to coexist with devices operating under the regulations as proposed in the NPRM. Ultra-wideband's (UWB) unique benefits and utility to society must be preserved. All existing Part 15 devices must be taken into account when introducing new Part 15 devices, as indeed was done in the past when introducing licensed services.

Decawave urges the FCC to only award the minimum amount of spectrum required at a frequency as much below 6.0 GHz as possible.

The sharing studies show that duty cycle restrictions and transmit power control are required to limit the potential of interference. Based on studies by the companies in favour of the NPRM, we suggest a duty cycle limit of 0.5% over at most 1 second is included in the rules.

With regards to transmit power, we would like broadband access systems to use the spectrum more efficiently. Since there are already plenty of allocations where high transmit power is allowed, we ask to limit e.i.r.p in the 6 GHz band to 0 dBm to promote frequency reuse. With such a reduced transmit level, complicated and unproven AFC solutions may not be required.

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1 INTRODUCTION

Decawave welcomes this opportunity to comment on the FCC's Notice of Proposed Rulemaking in ET Docket 18-295.

Decawave is a developer and supplier of Impulse-Radio Ultra-Wideband (IR-UWB) semiconductor devices designed to operate under FCC PART 15 Subpart C Section 15.250 (the so-called wideband rules) and/or under Subpart F (the ultra-wideband rules). One of the key application areas of the current deployments is real-time location systems, including secure access for vehicles.

Most of Decawave's customers operate in the 6 GHz band[1]. This is due in large part to the availability of the less restrictive 15.250 wideband rules and the favourable coexistence conditions with the highly directional, outdoor primary services in this frequency range. The regulatory regime in other regions also makes 6 GHz band most attractive for internationally traded products.

In this contribution, Decawave highlights a number of concerns that the company and its customers have with regards to the NPRM. Introduction of the rules proposed will seriously degrade the ability of our products to operate satisfactorily in the 6 GHz band.

2 THERE IS NO SHORTAGE OF UNLICENSED SPECTRUM

The rationale behind this NPRM seems to be the fact that the proponents have convinced the powers that be that there is a shortage of unlicensed spectrum, especially in light of the upcoming wave of IOT applications.

Decawave would like to point out that the ultra-wideband rules (FCC Part 15 Subpart F) already allow unlicensed use between 3.1 and 10.6 GHz. Several companies in the early 2000s developed solutions that were able to provide high-data rate, short-range communication systems that were ideally suited for wirelessly terminating the last 10 metres of many internet connections (so-called Wireless-USB/WiMedia/etc.). It is important to note they were able to do so without causing any harmful interference to other users of the spectrum.

Furthermore, the assumption that all or even most IOT applications will be based on broadband access and Wi-Fi technology is incorrect. For many applications, the power consumption of Wi-Fi systems is simply much too high to support the several years of independent (battery) operation they will require. Part of the reason is that Wi-Fi has concentrated on high-data rate applications while the majority of IOT devices generate only a few kilobytes per day at most.

Decawave sees UWB as a natural choice for IOT and potentially playing a major role in many of the IOT application areas and use cases. Primarily this is because of UWB's capacity for accurate location and accurate proximity detection, where many IOT use case are dependent or enhanced by knowing the location of the IOT devices. Another reason is that it is generally quite efficient in terms of energy per bit and so can be a good choice for moderate volumes of data transfer. The pulse-based modulation of UWB is also generally immune to multipath effects.

This IOT potential cannot be realized unless coexistence with UWB is a factor in the new rules.

Decawave, as a company, has invested considerable effort to provide solutions within the existing framework of the regulations. The companies advocating for this rule change, rather

[1] From 6 to 7 GHz, where IEEE 802.15.4 HRP UWB PHY channel 5 is centered on 6489.6 MHz.

than also investing in innovative technology that operates within the existing rules, instead use their brand-name recognition and market dominance in an attempt to force changes to the rules to suit their existing technology.

3 UWB SYSTEMS WILL NOT BE ABLE TO CONTINUE TO COEXIST

In the NPRM, the FCC writes that it expects that unlicensed wideband and ultra-wideband system will continue to coexist with all other systems, both licensed and unlicensed, within the 6 GHz band. In its contribution, IEEE 802[2] has already acknowledged that coexistence between UWB and broadband access in the 6 GHz band is a problem with no obvious solution. In the annex to this contribution, Decawave reports the results of coexistence studies that show that the expectation of continued coexistence is unfounded.

A minimum coupling loss calculation shows that systems under the proposed regulations can interfere with UWB reception over distances well over half a mile away. This is primarily due to the close to 1,000,000 times greater transmit power density of the proposal compared to the UWB limit.

For aggregate interference studies, the annex to this contribution considers four broadband access deployment scenarios.

3.1 Interference study A: Based on proponents' assumptions

The first of these scenarios is based on the RKF study submitted by the consortium of Wi-Fi companies.

The RKF study has a time horizon up to 2025 and therefore considers a market share of 45% for 6 GHz enabled broadband access devices. However, sharing studies should give confidence to existing users much further into the future and a market share of 95% 6 GHz enabled devices is therefore used.

As detailed in the annex, the power levels also have been adjusted to comply with the proposed regulations in the NPRM.

The results of this study show there is already a considerable probability of interference to the UWB receiver under these assumptions. Within CEPT ECC SE45, a limit of -78 dBm was used based on measurements provided by ETSI, corresponding to the level at which the UWB receivers experience a 3 dB sensitivity reduction. The study predicts the probability that this level is exceeded is up to 0.3% in the scenarios considered.

3.2 Interference study B: As with study A above, but with no restrictions on power control

The RKF study assumes a certain distribution of the transmit power levels, and particularly assumes that higher power levels are rarely used. However, the regulations currently proposed in the NPRM don't prescribe any transmit power control. Experience in other U-NII bands has shown that this quickly leads to an arms race where most access points will transmit at the highest power levels. Assuming that 90% of devices transmit at the highest level allowed leads to significant increase in the probability of interference. The likelihood that -78 dBm limit will be exceeded increases to 0.5%..

[2] See comments from IEEE 802 LAN/MAN Standards Committee in ET Docket 18-295, Dec 12, 2018

3.3 Interference study C: As with study A above, but with no limit imposed on duty cycle

The RKF study is based on the assumption that users have one highly active device, with a duty cycle of 0.44%, and 9 low activity devices, with duty cycles of 0.00022%. However, the proposed regulations contain no restrictions on the duty cycle or the number of devices per person. Moreover, the number of devices and their usage pattern seems to be based on current applications. While it remains unknown what future applications will be, it is certain new ones will appear. To take this into account, an alternative scenario where the high activity devices have a 5% duty cycle and the low activity devices a 1% duty cycle was also considered. Under these assumptions, there is a large increase in the likelihood of interference. The probability of surpassing the -78 dBm level increases to 7%.

3.4 Interference study D: As with study A above, but without duty cycle or power control restrictions

This final deployment assumption combines no transmit power control with the increased duty cycle. As would be expected, this leads to the worst interference probability, and, this is allowed under the regulations as currently proposed. The likelihood of going beyond the -78 dBm limit, and thereby reducing the receiver sensitivity by more than 3 dB, is around 12% which would cause at least 32% of typical, three message, two-way ranging exchanges to fail. This is a catastrophe for real time location monitoring.

3.5 Conclusion

Even under the advantageous RKF assumptions, the performance of UWB systems will be adversely affected. To prevent the prohibitively high likelihood of interference under the alternative deployment scenarios, Decawave asks the FCC to set lower emissions limits and include transmit power control and duty cycle restrictions in the regulations. Since current transmit power control regulations (15.407) are only mandatory for transmissions above 500 mW e.i.r.p, Decawave asserts that these requirements must be stricter in the 6 GHz band.

Table 1: Summary Aggregate interference results

	Probability interference level exceeds -78 dBm			
Scenario	**Study A**	**Study B**	**Study C**	**Study D**
Apartment block	0.279%	0.491%	7.096%	12.522%
City-wide	0.123%	0.509%	2.966%	11.636%

4 UWB'S UNIQUE BENEFITS MUST BE PRESERVED

The wide bandwidth available under FCC Subpart C 15.250 and Subpart F have given rise to devices with unequalled capabilities for accurate and real-time localisation systems. These systems are used in a wide variety of low cost, low complexity applications, offering previously unavailable benefits to society.

With the advent of IOT, location awareness has become ever more important. Much of the resulting data is worthless without knowledge about its precise origins and location.

The sharing studies in the annex and the summary above show that these UWB applications are under serious threat. The FCC has previously taken the interests of Part 15 devices into account when introducing new licensed technologies[3]. Since the current NPRM concerns the introduction of another Part 15 system, the interests of users operating under the existing rules should be taken into account. The benefits and utility of systems based on the UWB rules must be preserved.

Decawave is only one of the more recent providers of UWB products. While earlier solutions were based on discrete components, Decawave were the first to offer an integrated circuit solution. We can see how this has given UWB extra momentum. Since the launch of our first chip in 2013, it took until 2016 sell the first 1 million chips, to 1000 customers. Growth is accelerating; last year, we had sold over 7 million units to more than 4000 customers. At first, the applications were mainly pure real-time localisation systems, where UWB is for example used to provide geo-fencing to protect workers from dangerous machinery. The capability to secure the ranging measurements is now also opening up many more consumer-oriented applications and attracting attention from big vendors.

The Keyless Entry Systems Market for cars is predicted to Reach US$ 8.3 Bn by 2026[4]. Keyless entry was standard equipment on 62 percent of US cars sold in 2018, up from 11 percent in 2008, according to car-buying advice site Edmunds[5]. This new technology has a downside. Thieves are using wireless relay attacks to fool the car into opening for them. The rate at which cars are being stolen in the US — which measures volume of vehicles against the U.S. population — also rose for a third consecutive year in 2017, reaching its worst point since 2010. In 2017 there were 773,139 vehicle thefts.

The not for profit, consumer protection association “Which?” analysed research from the General German Automobile Club (ADAC) to find out the impact of keyless attacks on five best-selling cars[6]. It found that 230 of the 237 vehicles tested, from more than 30 brands, could be unlocked and started using relay boxes, while a further four models could be either unlocked or started. The only three keyless cars ADAC tested that were not susceptible to relay attacks were from Jaguar Land Rover – the latest models of the Discovery and Range Rover, and the 2018 Jaguar i-Pace. Jaguar Land Rover have switched to using UWB to securely determine the distance between the key fob and the car.

All the major car manufacturers are following this and are scheduled to launch their systems in 2020/2022 time frame if not earlier. Within IEEE 802.15.4z, Decawave and others from the UWB community are working with car and phone manufacturers to standardise these systems.

Contactless payment is currently vulnerable to the same type of relay attack that has plagued keyless entry and, as a result, these types of payments are often limited to about $30. The NFC Forum is proposing to introduce UWB in their next generation products to secure payments. Phone manufacturers are designing these UWB applications in models that will reach the market in the very near future. All this implies that the market will soon be tens of millions of units per year and reach hundreds of millions by 2025 at the latest.

[3] See Authorization of Spread Spectrum and Other Wideband Emissions Not Presently Provided for in the FCC Rules and Regulations, Gen Docket No. 81-413, 101 FCC 2d 419 (1985); see also Revision of Part 15 of the Rules Regarding the Operation of Radio Frequency Devices Without an Individual License, GEN. Docket No. 87-389, First Report and Order, 4 FCC Rcd 3493 (1989).

[4] According to Persistence Market Research, see https://www.prnewswire.com/news-releases/keyless-entry-systems-market-to-reach-us-83-bn-by-2026---persistence-market-research-683856701.html

[5] What you need to know about keyless ignition systems, https://www.edmunds.com/car-technology/going-keyless.html

[6] See e.g. https://edition.cnn.com/2019/01/28/europe/keyless-car-theft-scli-gbr-intl/index.html

5 AN ALTERNATIVE PROPOSAL

The sharing studies have shown that a duty cycle restriction and transmit power limits are necessary to contain the potential for interference. Based on the duty cycles advanced by the supporters of the RKF study, Decawave propose that a 0.5% duty cycle limit[7] per access point is enforced by regulation, i.e. written into any new rules. Since this study and its parameters have been suggested by the RLAN proponents, the Commission should reasonably infer the 0.5% duty cycle limit is sufficient to support their applications. Imposing such a limit will also help to curtail interference to other services. To provide sufficient gaps for UWB and other devices to get through, as well as to enable easy verification, we suggest the 0.5% applies to periods of at most a second.

The sharing studies have clearly shown the need to limit high power emissions. The limits proposed in the current NPRM do nothing to address the interference potential in this way. By simply adopting the same power levels of the other U-NII bands, the RF pollution that has led to congestion there will spread to the rest of the spectrum as well. Avoiding this will, at a minimum, require that strict transmit power control rules be introduced for both access points and client devices.

Furthermore, Decawave believes a diversification of the rules will lead to more efficient use of the spectrum and more innovation. There is already plenty of spectrum available for unlicensed broadband services at high power levels, both in the 2.4 and 5 GHz bands, and in the 60 GHz range. We would like to see broadband access systems embrace similar frequency reuse techniques as those that have led to increased spectrum efficiency in cellular systems. We therefore urge the FCC to restrict the e.i.r.p in the 6 GHz band to no more than 0 dBm (which in a 160 MHz bandwidth would still be a spectral density 32 times higher than that allowed for UWB). This power level supports short-range high data rate broadband access and lower power IOT use. More importantly, it also enables frequency reuse and promotes innovative solutions that support much more efficient spectrum usage. A low emission level may also eliminate the need for complicated AFC mechanisms.

Decawave understands that the Mobile Now Act requires FCC to assign more spectrum to unlicensed services. However, there is no requirement to assign anything approaching the 1200 MHz of spectrum proposed in this NPRM. Given that Wi-Fi already has plenty of spectrum and there is controversy over simply broadly expanding it to include the 6 GHz band, Decawave urges caution, and recommends only awarding the minimum amount required. To preserve the current RTLS installations operating under Part 15 Subpart C 15.250, we would like the additional spectrum required under the Act be allocated at as low a frequency as possible and avoid the spectrum above 6 GHz. To promote true innovation and to protect other spectrum users, we believe any further unlicensed broadband use should be required to employ the ultra-wideband rules from Subpart F. The needs of many IOT applications are met much more efficiently and effectively by UWB technology, which has already been proven, in the real world, not to interfere with the incumbent primary users.

6 CONCLUSIONS

In the past, Part 15 devices have been considered when introducing licensed services. Based on that precedent, the same considerations should apply when contemplating new unlicensed Part 15 use, including this NPRM.

UWB applications will not be able to coexist under the rules proposed in this NPRM. If they were to become reality, society will lose the benefits of fast, power-efficient localisation

[7] These duty cycle restrictions could follow the European Low Duty Cycle (LDC) mitigation template used for UWB devices, see Annex 2 to ECC Decision (06)04

currently offered by UWB based real-time localisation systems, including important safety and security applications.

The rules as currently proposed fail to ensure that interference, even to primary services, will be limited. To mitigate against this, Decawave proposes the introduction of a 0.5% duty cycle limit per access point and mandatory transmit power control.

Between the existing U-NII and ISM bands at 2.4, 5.x, and 60 GHz, Decawave believes there is sufficient unlicensed spectrum available for high power broadband access. Lower power applications should be encouraged and can make use of the huge amount of unlicensed spectrum offered by Part 15 Subpart F ultra-wideband rules. The extra spectrum awarded under this NPRM should therefore be limited to the minimum mandated and at the lowest possible transmit power. We propose an e.i.r.p limit of 0 dBm, preferably in a band entirely below 6 GHz.

ANNEX – SHARING STUDY RESULTS

In this annex, Decawave reports on the sharing studies it conducted. These are to a large extent based on similar studies conducted within CEPT ECC SE45, with some obvious modifications to take into account the different regulatory proposals.

The RLAN deployment assumptions are based on those listed in the RKF study (https://s3.amazonaws.com/rkfengineering-web/6USC+Report+Release+-+24Jan2018.pdf). However, whereas the RKF study appears to have a time horizon of 2025 and therefore considers a market share of 45% for 6 GHz enabled RLAN, sharing studies should give confidence to existing users much further into the future and a market share of 95% 6 GHz enabled RLAN is therefore assumed.

Furthermore, as many of the RKF assumptions, in particular with regards to duty cycle and transmit power control, are not included in the regulations as currently proposed, alternative sets of assumptions are also evaluated to show the sensitivity of the results to these assumptions.

1 RLAN DEPLOYMENT ASSUMPTIONS

1.1 Study A: RKF-like assumptions

In first instance, the RLAN deployment characteristics from the RKF study (https://s3.amazonaws.com/rkfengineering-web/6USC+Report+Release+-+24Jan2018.pdf) are followed. However, as mentioned above, a market share of 95% for 6 GHz enabled RLAN is used. A further small modification takes into account that the current regulations don’t allow transmissions at 4 W.

For completeness, the relevant assumptions are listed below.

Each person is assumed to have 10 RLAN devices. Ten percent are high activity devices, with a duty cycle of 0.44% in the busy hour, while the remaining ninety percent of devices are low activity devices with a duty cycle of 0.00022% per hour.

As discussed above, and unlike the RKF study, 95% of RLAN devices are assumed to 6 GHz enabled. Based on the ratio of available bandwidth, 68% of those devices is assumed to be actually operating in the 6 GHz band.

Only 2% of the devices operate outdoors, with the remaining 98% used indoors.

The RLAN power distribution was modified slightly to take into account that the proposed rules don't allow 4 W transmissions. It was therefore assumed that these transmissions will also take place at 1 W. Based on table 3-7 and 3-8 of the original RKF report, the power distributions then become:

Table 2: RKF-like RLAN e.i.r.p. distribution

EIRP (mW)	**1000**	**250**	**100**	**50**	**13**	**1**
Indoor	0.67%+0.42%	10.39%	6.49%	24.64%	51.84%	5.56%
Outdoor	2.83%+2.02%	9.45%	9%	32.13%	41.99%	2.58%

In the frequency bands where the regulations don’t allow 1000 mW transmissions, it is assumed these will take place at 250 mW instead.

The RKF study assumes the RLAN devices will operate in compliance with IEEE 802.11 in bandwidths of 20, 40, 80 and 160 MHz. The probability of a certain bandwidth being used is given in table 3-9 in the RKF report, which is reproduced here for completeness:

Table 3: RLAN bandwidth distribution

Bandwidth	**20 MHz**	**40 MHz**	**80 MHz**	**160 MHz**
Percentage	10%	10%	50%	30%

1.2 Other assumptions

While the RKF assumptions are based on current IEEE 802.11 deployment scenarios, other RLAN systems and deployment scenarios are possible under the proposed regulations. In particular, the regulations don't restrict transmit power and duty cycle.

Apart from transmit power and duty cycle, all other RLAN deployment assumptions, including the number of high and low activity devices per person, are unchanged as compared to the RKF study. The indoor/outdoor ratio and bandwidth distribution of the RKF studies have been preserved, however it is currently not known whether these are representative of future applications.

1.2.1 Study B: No transmit power control

The proposed regulations don't require transmit power control and certainly can't specify the distribution assumed in the RKF study. The regulations can't require systems to comply with any version of the IEEE 802.11 standards either and even the systems that do often don't use transmit power control.

The transmit power distribution proposed in the RKF study is therefore highly questionable. As an alternative, in order to study the impact of transmit power control, the following alternative power distribution is therefore also considered and contrasted to the RKF-like results:

Table 4: Alternative RLAN e.i.r.p distribution

EIRP (mW)	**1000**	**250**	**100**	**50**	**13**	**1**
Indoor	90%	2%	2%	2%	2%	2%
Outdoor	90%	2%	2%	2%	2%	2%

In the frequency bands where the regulations don't allow 1000 mW transmissions, it is assumed these will take place at 250 mW instead.

All other RLAN deployment assumptions, in particular with regards to the bandwidth distribution and number of high and low activity devices per person are not changed.

1.2.2 Study C: Increased duty cycle

The proposed regulations don't contain any restrictions on the duty cycle of the RLAN access points. To evaluate the influence of duty cycle on interference to existing users, an alternative deployment scenario in which high activity devices are assumed to have 5% duty cycle, while low activity devices have a 1% duty cycle is also considered.

1.2.3 Study D: Combining no TPC and increased duty cycle

While the previous two alternative deployment scenarios allow evaluation of the relative merits of duty cycle restrictions and transmit power control, neither are currently included in the regulations and a combination of both therefore represents the most realistic deployment assumption.

2 SHARING STUDIES

2.1 Single interferer separation distance

In this section, the effect of the proposed RLAN transmissions on an UWB receiver is evaluated using a minimum coupling loss study. More detailed Monte Carlo simulations results are supplied in the next sections but in order to perform those an initial appreciation of the interference potential of the RLAN systems, as presented here, is helpful.

The UWB victim is assumed to have a 500 MHz bandwidth, centred on 6.5 GHz. The RLAN system transmits in-band, with an EIRP of either 250 or 1000 mW. The propagation between the two systems is assumed to be free space.

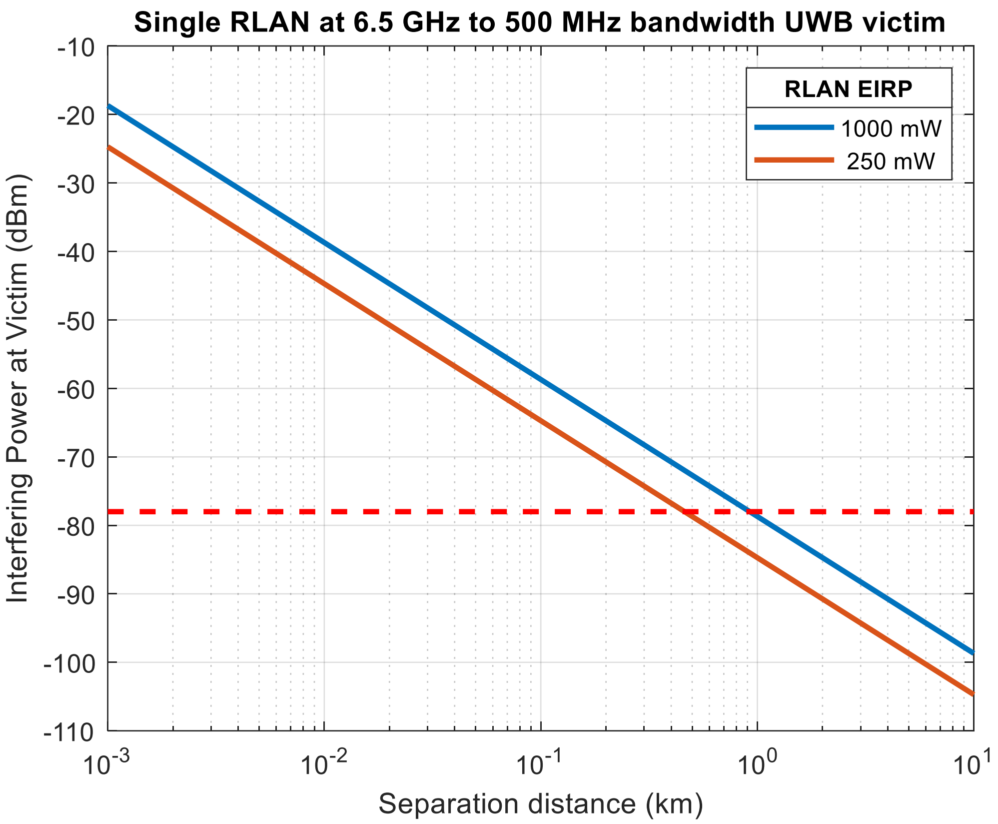

Figure 1: Single interferer separation distance

The RLAN system has the potential to interfere with UWB devices over huge distances.

The dashed red line is at -78 dBm. According to measurements conducted for CEPT ECC SE45 by Decawave and other ETSI members, this level results in a 3-dB sensitivity reduction for the UWB victim receiver. Higher degradation will occur for RLAN devices closer than 946 metres transmitting at 1000 mW and closer than 473 metres when transmitting at 250 mW.

2.2 *Aggregate interference - apartment block*

In this section, the aggregate interference of RLAN transmitters on UWB systems is evaluated using Monte Carlo simulations for an apartment block scenario.

The individual apartments are assumed to occupy an area of 10 by 8 metres. On average, there are 3 occupants per apartment. The apartment block consists of 10 floors, each 3.5 metres high, with two times ten apartments back to back on each floor.

For every iteration, the UWB receiver is randomly located within the building. Similarly, RLAN transmitters are randomly spread throughout the building according to the various deployment assumptions discussed above. The total RLAN interfering power at the UWB receiver is calculated using the indoor path loss model from IEEE 802.11ax channel model B (IEEE 802.11-14/0882r4), as was agreed with the RLAN community within CEPT ECC SE45. Following the model, a wall penetration loss of 5 dB is used. Only RLAN transmitters that overlap with the UWB bandwidth are considered. This conservative assumption implies physically impossible brick-wall filtering in the UWB receiver and infinite out-of-band suppression in the RLAN transmitters.

Every curve in the figure below is the result of half a million iterations of the Monte Carlo simulation. Like before, the line at -78 dBm is based on ETSI measurements and corresponds to the RLAN power level at the UWB receiver that results in 3 dB sensitivity degradation.

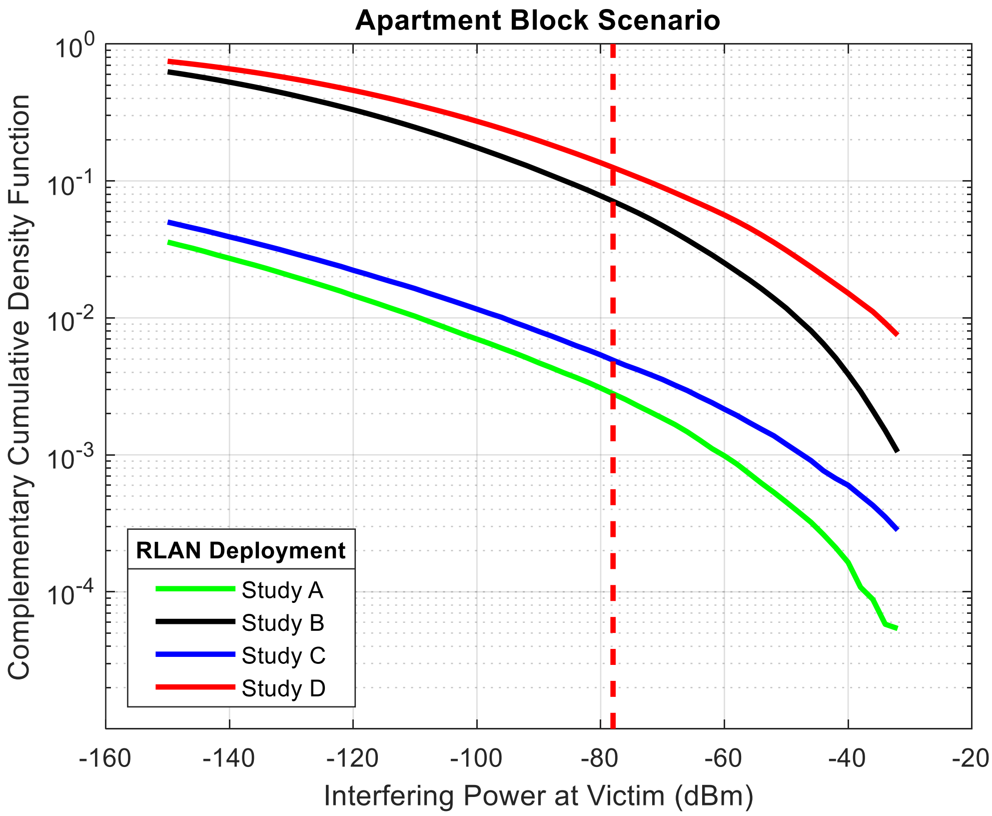

Figure 2: Aggregate interference, apartment block scenario

Table 5: Aggregate interference, apartment block scenario

Interfering power level	Study A	Study B	Study C	Study D
-78 dBm	0.279%	0.491%	7.096%	12.522%

The figure and extracted results in Table 5 show that even under RKF-like assumptions, a significant portion of UWB receivers would see their sensitivity degraded by more than 3 dB. Without transmit power control, the likelihood doubles to half a percent. However, the interference rises dramatically when the duty cycles are increased. With transmit power control, around 7% of the UWB receivers will experience more than 3 dB sensitivity degradation, while without TPC, the probability jumps to 12.5%.

These results clearly show that to limit interference to UWB and other existing 6 GHz users, transmit power control and, in particular, a duty cycle restriction need to be added to the proposed regulations.

2.3 Aggregate interference – city-wide scenario

This aggregate scenario considers an inhabitant of a large urban city is using a UWB receiver. Since population statistics for London are publicly available (2017, https://data.london.gov.uk/dataset/london-borough-profiles), those characteristics of London will be used. No future extrapolation of the population data has been performed, while it is well known that the population of cities is increasing. The results should therefore be considered a conservative estimate.

The results of the single interferer evaluation show that RLAN transmitters located close to the UWB victim receiver are most harmful. Therefore, Monte Carlo simulations are performed with the UWB receiver at the centre of a circle with an area of 1 km^2.

RLAN devices are randomly spread throughout the area by combining the population density with the various deployment assumptions listed above. Only RLAN transmitters that overlap with the UWB bandwidth are considered. This conservative assumption implies physically impossible brick-wall filtering in the UWB receiver and infinite out-of-band suppression in the RLAN transmitters.

The RLAN devices are distributed in height according to the urban distribution from the RKF study.

The site general path-loss model for propagation between terminals located from below roof-top height to near street level from ITU-R P.1411-9 is used as this has also been agreed with the RLAN community in CEPT ECC SE45. A fifth of the UWB receivers are assumed to be outdoors. As in the RKF study, buildings have 20% probability of being thermally efficient, with a building entry loss of 32.2 dB. Otherwise, the building entry loss is assumed to be 16.7 dB.

The results of the Monte Carlo are shown in the figure below. Five hundred thousand simulations have been performed per curve. Based on measurements performed for ETSI, the red line at -78 dBm corresponds to the power level at which RLAN interferers cause 3 dB sensitivity reduction.

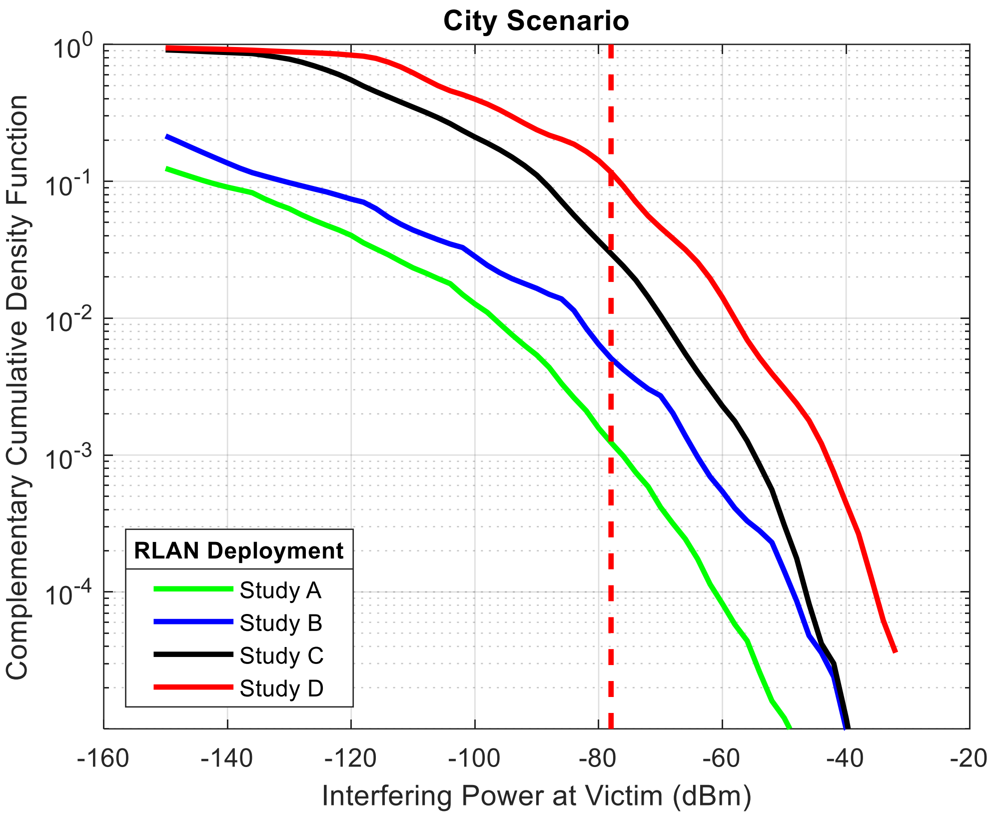

Figure 3: Aggregate interference – city-wide scenario

Table 6: Aggregate interference – city-wide scenario

Interfering power level	**Study A**	**Study B**	**Study C**	**Study D**
-78 dBm	0.123%	0.509%	2.966%	11.636%

As in the apartment block scenario, the UWB victim already has a significant probability of interference under the RKF deployment assumptions. Compared to the apartment block, the city has fewer people close by and more and larger distances. The absence of transmit power control therefore leads to a relatively higher increase in interference, while the increased duty cycle still causes a big increase as well. When those two are combined, the likelihood of interference reaches about the same level as in the isolated apartment block.

Again, these results demonstrate that the proposed rules must be expanded to include both transmit power control and duty cycle restrictions in order to limit interference to UWB systems and other 6 GHz band users.